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Medical and Surgical Evaluation and Care of Illness in Space

Final Report for the NASA Contract NAG9-567, BASIC
"Non Invasive Techniques for Critical Ill in Space"

John H. Siegel, M.D.
Principal Investigator

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Progress Report

This report summarizes the work done on the contract NAG9-567, which was activated at the New Jersey Medical School-UMDNJ in April 1992 and carried on during the 1992-93 year to the present 1993-94 year which was terminated in May 1994. During this period the funding supported a single programmer under the direction of the Principal Investigator. Together they completed the initial examination stage of an interactive program for the recording of physical and physiologic injury information obtained from examination of an injured person, who might be an astronaut sustaining traumatic injury, due to a burn or physical trauma, either in space or in an earth bound training environment.

Additional studies had been planned for the conversion and testing of the previously designed physiologic monitoring modules in a bedside environment. However, the funds for the required physiologic evaluation nurse and the necessary equipment which had been requested were not granted and the contract was therefore limited, by mutual consent between the NASA project officer and the project principal investigator, to the development and limited clinical testing of the patient injury modules. During the present contract an interactive graphic methodology was developed to permit the delineation and recording of serious injuries with regard to cause and severity and their location on the body surface. The system also permits the recording of admission physiologic and biochemical data. These interactive graphic modules also permit

the recording of a full neurological examination and the delineation of the location, nature and complexity of skeletal system fractures which might be the result of a traumatic insult.

In addition, as a demonstration of the therapeutic information capability of this system, program modules were created which provide relevant therapeutic protocols and suggestions for management of acute problems which might arise in post trauma victims. The examples shown are for individuals with severe body burns of second or third degree severity, or for patients who have sustained major barotrauma. These medical information (Rx) modules were designed as demonstrations of the type of clinical therapeutic guidelines related to specific injuries that can be provided by this computer program. These therapeutic guidelines would allow a paramedically trained astronaut, or a physician astronaut with limited experience in handling the trauma condition in question, to immediately initiate therapy within an environment where Earth to Space station communications might be limited because of the very events that which might have precipitated the trauma to the personnel involved (e.g., explosion, fire, etc.). They provide systematic guidance for urgent therapy which can then be modified as the condition progresses, by appropriate ground consultation using the quantitative information provided by the interactive graphic delineation of patient injuries and the resulting physiologic abnormalities.

In this report the three aspects will be discussed: 1) The first is a description of the system of diagnostic examination graphics; 2) the second is a description of the organization of the therapeutic advisory systems with a demonstration of two specific

modules; and 3) the third is a brief technical description of the organization of the programming system carried out on a UNIX based work station using a WINDOWS environment.

A. THE DIAGNOSTIC EXAMINATION INTERACTIVE GRAPHICS PROGRAM

This Diagnostic Examination system is a group of interrelated programs which enables and guides the recording of the details of the physical examination of an injured or burned astronaut, or civilian trauma patients. It was designed to be utilized by paramedical or medical trained personnel who might have a relatively limited experience in the evaluation of the seriously injured patient. Therefore, it is based on the utilization of a consistent diagnostic graphic format based on a series of body images which can be addressed by the examiner in a systematic fashion so as to record those abnormalities noted on direct physical examination, or on the basis of information that might be obtained by specialized diagnostic equipment providing radiologic or ultrasound imaging. It also permits the introduction of biochemical and physiologic information that might be obtained from standard biochemical analytic devices or physiologic sensors. These data can be entered either directly as digitized inputs from a physiologic sensor system or by manual entry of appropriate numbers which quantify these parameters of physiologic function, such as the blood pressure or heart rate, etc. Since in a NASA environment, the astronauts could be examined prior to space flight and at various intervals during the in-flight training and recovery period, the system is designed to permit serial recordings of

basic information which can then serve as a base line for the interpretation of later abnormal changes.

1. BODY IMAGE - GENERAL CONSIDERATION AND ORGANIZATION

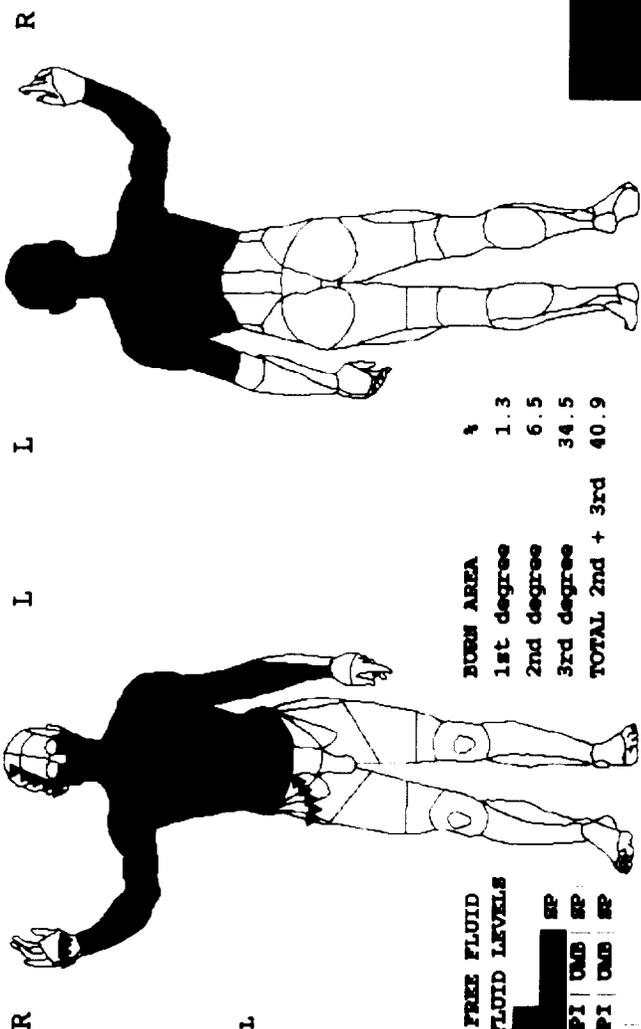
The initial diagnostic format is shown in Figure 1. This image and its accompanying graphic "hot buttons", are presented on the computer screen and can be accessed by the use of a mouse or trac ball cursor. This first image demonstrates an anatomic diagram of the front and back of the body surface delineated into identifiable regions for localization of injuries or other abnormalities. It is important to note that all of the various diagnostic formats can be called to the screen by placing the mouse driven pointer on one of the specific icon names at the bottom of the screen. These allow for the selection of images relevant to injuries to the body surface area (Skin/Body), head, face and brain (Skull/CNS), skeletal injuries (Skeleton) or neurologic injuries which involve the spinal cord (Spinal Cord). Injuries to the thoraco-abdominal viscera can also be delineated, but this module (not shown) is designed for use in a hospital bound environment, since it is unlikely that these organ injuries could be definitively delineated in the proposed Space Station.

However, in all cases the examiner is forced to begin the recording of the diagnostic session with the body surface image and physiologic data obtained on first examination after the trauma (Figure 1). This body surface image is use to enter the findings of the initial physical examination and is of considerable importance in the diagnosis of all the

Name Last **SMITH** First **JOSEPH** Age **44** Weight **100** kg; Sex **M** Race **M**
 Height **5** ft; **4** in; Hospital ID **00078789** Trauma No **01010** SS# **217-29-31**
 INS carrier **US CASUALTY** INS no **234348678**
 Address **45 WEST LAURENCE ST** City **NEWARK** State **NJ** Zip **07103**
 ADM Date **6/30/94** Time **11:54** Exam Date **11:54** 06/30/94
 MVC PEDEST MCA GSW SHOTGUN STAB FALL INDUST HOME BMSO TR
 BURN FLAME ELECT. CHEM. BP **100** / **65** HR **120** RR **24** Hgb **14** Hct **55**
 wbc **23000** PLAT **130** PTT **93** F102 **100** PaO2 **240** PaCO2 **45** pHa **7.35** BE **-0.6** Lect **9.0**

Stab wound
 EXPANDING PULSATILE
 CHEST EXAM + X-RAY
 FLAIL CHEST L STERNUM
 PARIETAL LESION RL RM LU LL
 TRACHEAL SHIFT R L
 PNEUMOTHORAX L
 HEMOTHORAX R L
 SUCKING WOUND R L
 HEART SOUNDS + - 0
 MEDIASTINUM ++ - N

ABDOMINAL EXAM + X-RAY
 PHYSICAL + X-RAY SOFT FREE AIR FREE FLUID
 DISTENDED + - N AIR-FLUID LEVELS
 BOWEL SOUNDS ++ + - N
 TENDER RU RL LU LL EPI UMB EP
 RIGID RU RL LU LL EPI UMB EP
 REBOUND RU RL LU LL EPI UMB EP
 ERGASIS, NG BILE BLOOD
 RECTAL YERDIE GULAC+ BLOOD



BURN AREA	%
1st degree	1.3
2nd degree	6.5
3rd degree	34.5
TOTAL 2nd + 3rd	40.9

FIGURE 1

traumatic injuries considered. As shown in Figure 1, the WINDOWS format for the delineation of the nature and location of traumatic injuries is designed to produce a clinical record which would replace other types of paper records and more important, all of these images can be directly communicated by microwave transmission to a similar computer in a distant earth bound location, so that consultation with a more experienced Trauma Surgeon can be obtained. Since all locations of anatomic parts or injuries are delineated by a vector location system. It is only the vector points which need to be transmitted, since the resident program itself recreates the image. This allows for a very economical use of the system and reduces the amount of information which would need to be transmitted by microwave, thus, preserving communications for other aspects of Space Station management and monitoring.

At noted, at the top of the graphic display [Figure 1] is space for the patient's demographic information, which can be entered via the keyboard. These data include the patient's name, an identifying unit number, social security number, a trauma or special NASA number as well as patient address and any insurance information as required. This information can be modified appropriately to fit the NASA record keeping system and could be pre-entered since the identity of each astronaut would be known in advance. The date of examination is automatically entered based on the time of the initial entry of patient examination information. In the case of serial examinations, successive images of each body system are created and filed, each with their own sequential time line of

information entry. On command, the examination time can be changed by the individual conducting the initial examination to reflect some earlier time period than the actual computer entry, if there has been a significant delay between the physical examination and the time of data entry. The sequencing of examinations with regard to time permits serial physical evaluations to be made with their exact times recorded. In this way, changes in patient status can be assessed and the rate of alteration in physical injury severity can be coordinated with physiologic studies obtained by non-invasive sensor systems and displayed in time sequential physiologic state diagrams as described in previous progress reports (1990-1992).

In conformity with the classification of injuries by the **E Code** utilized by the American College of Surgeons Committee on Trauma, the National Highway Traffic Safety Administration and the Fatal Accident Reporting System (FARS) and other data banks, the specific cause of injury, or the factors initiating the traumatic episode can be delineated by clicking the mouse pointer over the relevant trauma **E Code** designator at the top of the diagram. In this way, a wide variety of trauma conditions can be identified and the **E-Code** designation will influence the program selection the proper cautions and therapeutic suggestions. For instance, in the case of burns it is possible to indicate whether the burn injury has been produced by flame, chemical, or electrical insult, or any combination of these. Also, because of the importance of barotrauma due to decompression in space, a specific **E Code** delineator for barotrauma (**BARO TR**) has been created although

this is not part of the standard E Code designation.

As noted earlier, the physiologic and relevant biochemical information obtained on entry of an injured patient to the monitoring system can be recorded either by the examining individual using the keyboard, or directly entered from the physiologic monitoring system according to the time of examination. Direct entry from the automated laboratory system based on timed coding of the data can be also be carried out to enter these types of data as well. This then produces a physiologic profile which is of major importance in permitting the assessment of the physiologic and biochemical consequences of the injury and relating these to the physical injury with regard to categorizing the nature of the trauma and stratifying the trauma episode with regard to severity. The acquisition and recording of these data are critical to trauma severity staging, since all of the various scaling systems for injury severity utilize one or more of the physiologic and biochemical parameters contained on this list, as well as the specific anatomic information regarding the injury and its severity.

2. BURN INJURIES AND BODY SURFACE LOCALIZATION OF INJURIES

The physical examination data indicated in each of the various body images presented in this system are entered by the use of the mouse pointer (or other cursor manipulator) and qualified by user interaction with the various soft keys or "hot buttons" provided on the graphic surface. On the left side of the image shown in Figure 1, are a variety of these "hot buttons" in different colors. These permit the examining paramedic or physician to qualify the nature

and the degree of injury with respect to the region of the body surface specifically designated using the mouse or trac ball control cursor. With only a slight modification, it would be possible to use a touch sensitive screen with a pointer in exactly the same way. The system is designed to allow the "hot button" description to specify the injury to an area using the focal injury pointer (cursor) to locate the site of injury. For example in Figure 1, the location and degree of a body surface burn (first, second, or third degree) are indicated by placing the cursor over the specific body area after first activating the "hot button" for that degree of burn (1^0 , 2^0 , or 3^0). This can also be done for contusions lacerations, or various penetrations wounds to various body areas (Figure 2). Moreover, each designated region of the body is named with regards to its anatomic location so that a precise textual designation can also be developed for a written report. In the specific case of burns, as the areas burned are indicated and their severity quantified, the program automatically sums the second and third degree burn areas, both individually by degree and collectively, so as to automatically compute a total percent of body surface burn. This, as noted later in the therapeutic section, allows for the computation of an initial fluid therapy for the burn patient.

As shown in Figure 2, the examiner can also localize the point of contact injuries, such as penetrating injuries caused by gunshot, shotgun or stab wounds (or injuries which might be caused by small space objects travelling at a high speed that might penetrate the space suit and enter into the astronaut's body in the same manner as a gunshot). These local points of blunt or penetrating trauma can be designated by using the focal cursor

Name Last (erbed) First Max Age 44 Weight 74 kg; Sex M Race B
 Height 5 ft; 11 in; Hospital ID 727274 Trauma No 888
 INS carrier INS no
 Address City State Zip
 ADM Date 1/13/94 Time 11:28 Day Exam Date 11:24 01/13/94
 MVC PEDEST MCA GBW SHOTGUN STAB FALL INDUST HOME BARS TR
 BURN FLAME ELECT. CHEM. BP 80 / 60 HR 120 RR 30 Hgb 11.5 Hct 32
 wbc 12000 PLAT 97 PTT 42 F102 100 PaO2 75 PaCO2 49 pHa 7.34 BE -0.7 Lact 1.6

Stab Wound

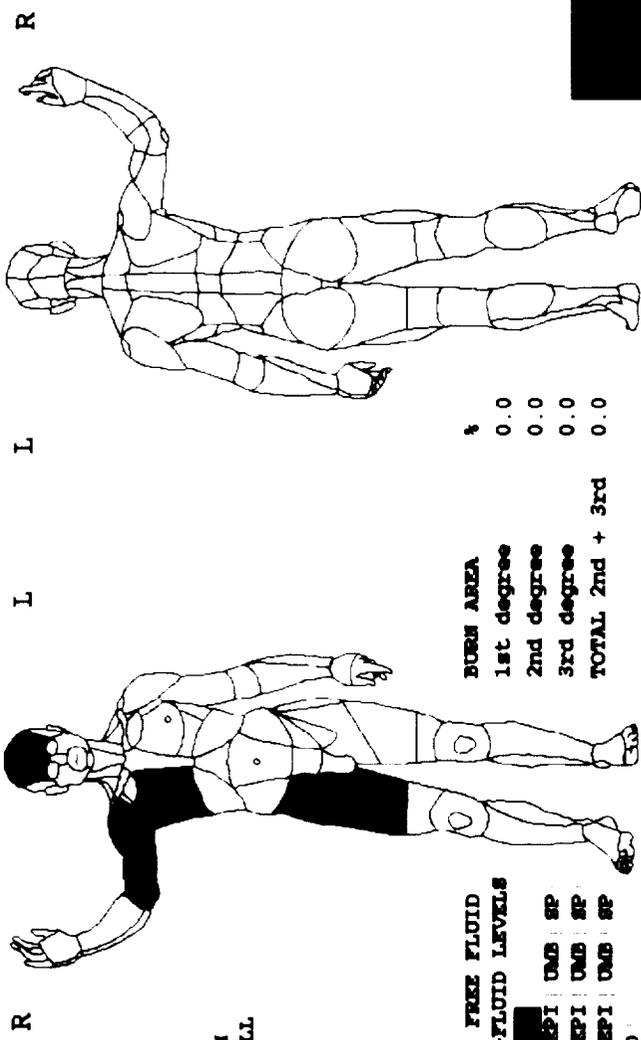
4 1/2 x 1/4 CM
PULSATILE

CHEST EXAM + X-RAY

FLAIL CHEST L STERNUM
 PARENCHYMAL LESION R M LU LL
 TRACHEAL SHIFT R
 PNEUMOTHORAX L
 HEMOTHORAX L
 SUCKING WOUND R L
 HEART SOUNDS + M 0
 MEDIASTINUM + M

ABDOMINAL EXAM + X-RAY

PHYSICAL + X-RAY SOFT FREE AIR FREE FLUID
 DISTENDED ++ N AIR-FLUID LEVELS
 BOWEL SOUNDS ++ + N -
 TENDER EPI UMB SP
 RIGID LU LL EPI UMB SP
 REBOUND LU LL EPI UMB SP
 EMESIS, NG BILE BLOOD
 RECTAL GULAC+ BLOOD



BURN AREA %
 1st degree 0.0
 2nd degree 0.0
 3rd degree 0.0
 TOTAL 2nd + 3rd 0.0

FIGURE 2

after activating the "hot button" for gunshot wound, stab wound, blunt trauma, deep laceration, etc. This places a specific symbol over the point or serial symbols along the course of entry. In a similar fashion exit (gunshot, etc.) wounds can be indicated by the symbol modified by a double image, over the point of exit of the penetration. This allows a precise designation of the body surface injury and/or its transcorporeal course to be related to deeper injuries of body organs or skeletal structures as shown in subsequent diagrams. Also as shown in Figure 2, surface blunt contusions, or superficial and deep lacerations can be designated and their precise localization across the body surface can be shown by pressing the "hot buttons" for these injuries and activating the cursor sequentially along the path of the actual laceration. If the surface injury has produced a deeper mass that can be palpated in a specific body location it can also be designated by activating the specific mass "hot button" and the mass size and physical characteristics such as **expansion** or **pulsatility** can also be indicated.

3. CHEST AND ABDOMINAL EXAMINATION

The importance of these specific designation "hot buttons" is not only that they serve to record data, but also that they alert the examining individual to critical examination questions that need to be answered. For instance, the physician or paramedic is requested to provide information about chest wall stability, breath sounds, shifts of the tracheal and the presence of a physical diagnostically or physiologically demonstrable pneumo or hemothorax. The characteristics of the heart sounds and the presence of any mediastinal widening are also requested during the cardiovascular examination. The abdominal examination is

delineated by recording the finding of specific signs and symptoms including information about the bowel sounds, the level of distension and the location of tenderness, rigidity or rebound. Radiologic or ultrasound identified presence of bowel air fluid levels or free intra abdominal air or fluid can be indicated. The presence and characteristics of any emesis can be designated and the results of a rectal examination including the presence of tenderness, or of overt or occult blood can be indicated. These specific pieces of information are critical to a complete physical examination in interpreting the severity of various types of injuries and if present they must be delineated by the individual who has done the examination. These additional data are then related to the physical examination characteristics with regard to the nature and location of injury in the program to provide the appropriate therapeutic or diagnostic advisories or warnings. These therapeutic advisories can be activated by placing the mouse pointer over the Rx block and activating it to provide the information related to the findings recorded. Examples of such therapeutic advisories will be shown for burn injury and for barotrauma in the therapeutic advisory section (Section B).

4 SKULL, FACE AND BRAIN INJURIES

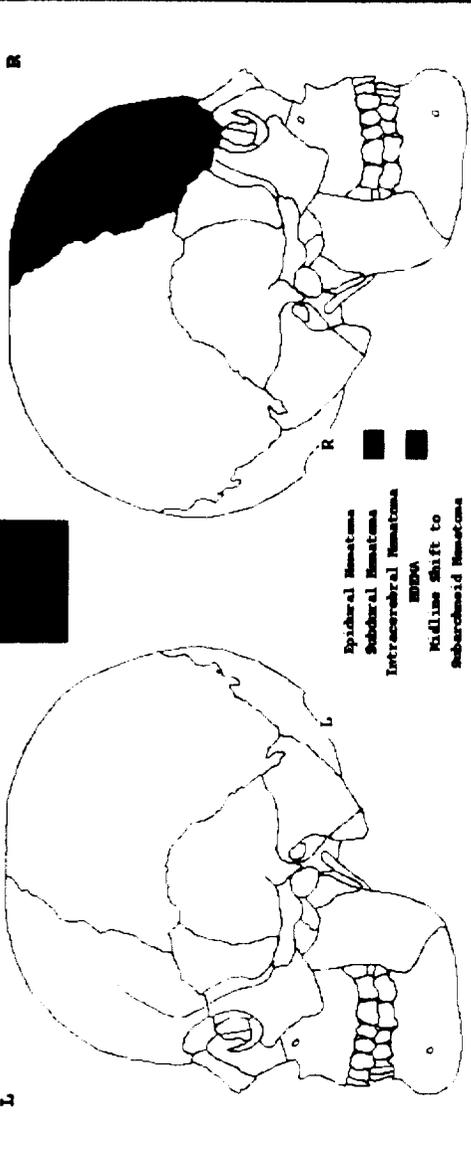
The second image screen shown in Figure 3 allows for the recording of physical and physiologic information related to injuries of the head, face and brain (Skull/CNS). In this image a right and left sided skull diagrams are presented so that face and skull fractures can be designated, together with a set of questions regarding the level of over all neurologic function. These observations represent the information required to develop and compute the Glasgow Coma Scale (GCS) Score. As the examining

Name Last: [redacted] First: [redacted] Age: 62 Weight: 99 kg; Sex: M Race: W
 Height: 5 ft; 4 in; Hospital ID: [redacted] Trauma NO: 1304 SSG
 ADM Date: 030993 Time: 1500 Day: [redacted] Exam Date: 10:02 01/19/94

Closed: 1 None 1 No Movement 1
 Open to Painful Stimuli: 2 Incomprehensible Sounds 2 Extensor Response 2
 Open to Verbal Stimuli: 3 Inappropriate Words 3 Flexor Response 3
 Spontaneously Open: 4 Confused Conversation 4 Withdraws from Pain 4
 Total GCS: 7 Oriented 5 Localizes 5
 Intubated 1 Obeys Command 5

Stab Wound
 Impaired by Alcohol: Both Present Both Normal Both Reactive
 Impaired by Drugs: Absent Right Dilated Right Reactive Right
 Dolls-eye Present: Absent Left Dilated Left Reactive Left
 Gag Reflex Absent: Both Absent Both Dilated Both Fixed

Frontal Sinus fx: L R Right LeftFort I II III Dural Lac C/Fg Leak L R
 Maxillary Sinus fx: L R Left LeftFort I II III Depressed Skull fx L R



- L R PARIETAL BONE
- L R OCCIPITAL BONE
- L R SPHENOID
- L R TEMPORAL BONE
- L R TEMPORAL PETROUS PORTION
- L R TEMPORAL MASTOID PROCESS
- L R TEMPORAL TYMPANIC PORTION
- L R ACOUSTIC MEATUS
- L R STYLOID PROCESS
- L R NASAL BONE
- L R SUPERIOR ORBIT
- L R LATERAL ORBIT
- L R INFERIOR ORBIT
- L R LACRIMAL BONE
- L R NASOETHMOID
- L R ZYGOMA
- L R ZYGOMATIC PROCESS
- L R MAXILLA NASAL-ORBITAL PORTION
- L R MAXILLA ALVEOLAR PORTION
- L R MANDIBULAR BODY
- L R MANDIBULAR RAMUS
- L R MANDIBLE CORAMOID PROCESS
- L R TEMPORAL MANDIBLE JOINT

M3 M2 M1 PM2 M1 M2 M3
 L L L L L L L L L L L L
 R R R R R R R R R R R R R R

Epidual Hematoma
 Subdural Hematoma
 Intracerebral Hematoma
 EPDVA
 Midline Shift to
 Subarachnoid Hematoma
 Intraventricular Hemorrhage

FIGURE 3

individual records these data, the Glasgow Coma Scale Score is automatically computed. Information such as whether an emergency intubation (T) has been carried out for airway control can also be entered to modify the Glasgow Coma Scale Score computation (Eg. GCS^{23T}). In addition other information relevant to the neurologic examination regarding pupillary sizes and levels of reactivity, the gag reflex, dollseyes, and the cold caloric response can also be indicated. Impairments of neurologic function secondary to drugs or alcohol can also be designated. These simple physical examination responses have been shown to have major prognostic significance for brain injured patients and also to be important with regard to determining the severity of brain injury and the necessary initial therapeutic response.

In addition by using the "hot buttons" and the mouse pointer it is possible to indicate the location and severity of the injuries to various bones of the face or skull. The detail of these injuries will of course be dependent on the accuracy of physical examination and the availability of diagnostic imaging capabilities, but these findings can be updated when there is the availability of more sophisticated equipment, either in the Space Station or after the patient been retrieved from space and subjected to detailed radiologic and neurologic examination in a fully equipped medical facility.

However, the important aspect of this system is that it allows all information to be integrated and presented so that diagnostic decision making can be made. In this regard the type of fractures to the bones of the skull or face can be indicated, (simple, comminuted, or compound and their combinations). For brain injury

it allows information that can be obtained from diagnostic imaging regarding the presence and location of intracerebral bleeding or epidural or subdural hematomas to be recorded and any resultant shift of midline structures. The nature of this information is of great diagnostic significance in determining the level of therapeutic response that may need to be initiated in a head injured patient.

5. SKELETAL INJURIES

The presence location and details of fractures to other bones of the skeletal system can also be indicated as shown in Figure 4. In this figure using the "hot buttons" and mouse cursor, the specific location of fractures and dislocations of various bones of the skeletal system including the vertebrae of the cervical, thoracic and lumbar spine, as well as the ribs can be localized and the type and complexity of the fracture indicated. In addition, other information associated with the fracture injury can be noted with regard to severity staging, so as to facilitate the decision making process regarding the urgency of therapy. For instance, the presence of segmental bone loss (B), or associated soft tissue loss (T) can be identified, and in very severe injuries any neurologic impairment associated with the specific injury (N) also can be designated. The presence and location of a traumatic amputation to an extremity can also be shown. All of these data can in turn be related to the information contained in the other imaging diagrams. This permits the examiner to relate the surface injury characteristics to the fracture or dislocation ligamentous injuries of the underlying skeletal structures. It is important to note that in these diagrams (Figures 2-4) data from real patients has been entered and the confirmation of the validity of these data has

Name Last: [redacted] First: [redacted] Age: 64 Weight: 99 kg; Sex: M Race: W

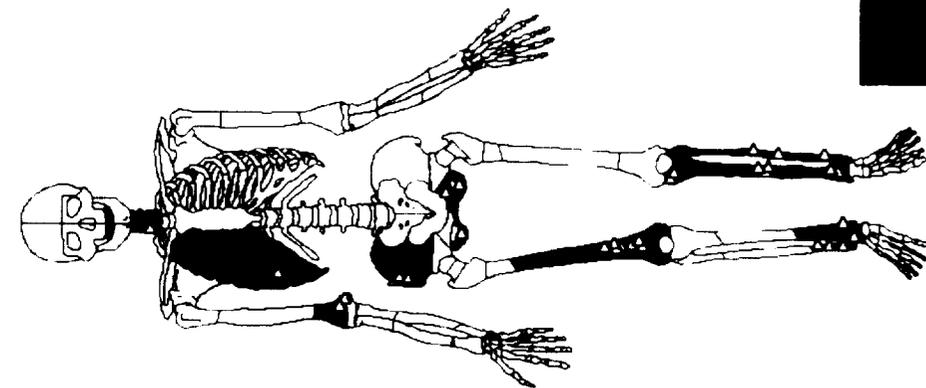
Height: 5 ft, 8 in; Hospital ID: [redacted] Trauma No: 1304 SSF: [redacted]

ADM Date: 030994 Time: 1500 Day: [redacted] Exam Date: 10:30 01/19/94

Cervical Spine
 Thoracic Spine
 Lumbar Spine
 Sternum
 Skull
 Face
 Jaw
 Clavical
 Scapula
 Ribs

Fracture Site

Cervical C5 Fracture
 Cervical C6 Fracture
 Rib Fr T7 Right



	R	L	R	L
Shoulder	F	B	T	M
Elbow	F	B	T	M
Wrist	F	B	T	M
Hip	F	B	T	M
Knee	F	B	T	M
Ankle	F	B	T	M
Midshaft Humerus	F	B	T	M
Distal Humerus	F	B	T	M
Elbow	F	B	T	M
Proximal Radius/Ulna	F	B	T	M
Midshaft Radius/Ulna	F	B	T	M
Distal Radius/Ulna	F	B	T	M
Hand	F	B	T	M
Sacrum	F	B	T	M
Ilium	F	B	T	M
Pubic Ramus	F	B	T	M
Ischium	F	B	T	M
Acetabulum	F	B	T	M
Femur Head	F	B	T	M
Femur Neck	F	B	T	M
Inter Troch. Femur	F	B	T	M
Sub Troch. Femur	F	B	T	M
Midshaft Femur	F	B	T	M
Supra Condylar Femur	F	B	T	M
Patella	F	B	T	M
Proximal Tibia/Fibia	F	B	T	M
Midshaft Tibia/Fibia	F	B	T	M
Distal Tibia/Fibia	F	B	T	M
Ankle	F	B	T	M
Foot	F	B	T	M

FIGURE 4

been made based on pilot studies utilizing severely injured patients treated in a Level I Trauma Center.

6. INJURIES TO THE SPINAL CORD RESULTING IN SPINAL CORD FUNCTIONAL ABNORMALITIES

The final completed image is related to the evaluation of individuals with suspected spinal cord injuries (Figure 5). The examining paramedic or physician can indicate the nature of the initiating injury and its location, if that is known, such as one that might be associated with an external wound produced by a sharp object or missile. The specific level at which a neurologic disfunction occurs can also be indicated on the neurologic body image and the presence of complete or partial motor, sensory and proprioceptive function can be indicated by touching the "hot button" and localizing the spinal cord level on the body image. Also whether the lesion is associated with similar abnormalities in neural cord segments distal to the site of the initial abnormality can be indicated. Through the system of indicators and colors noted on the diagram, this information can be recorded for visual presentation so that it can be compared with later examinations that might be made on the same individual over a time period while therapeutic modalities are being administered. In this way the presence of an incomplete lesion can be identified or a resolving or worsening lesion clearly delineated, so that a certainty of diagnostic evaluation can be obtained, clearly noted and recorded. For purposes of this demonstration an image is presented (Figure 5) in which there is partial motor and complete sensory loss on one side of the body compared with complete sensory and partial motor loss on the opposite side. Progression to complete motor, sensory and proprioception loss is shown in Figure 6.

Absent

Partial

Proprioception

Stab Wound



L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12

Name Last **WALSH** First **JOSEPH** Age **44** Weight **100** kg; Sex **M** Race **M**
 Height **5** ft; **11** in; Hospital ID **00078789** Trauma No **0101d** SS# **217-29-31**
 ADM Date **6/30/94** Time **Day** Exam Date **12:01** **6/30/94**

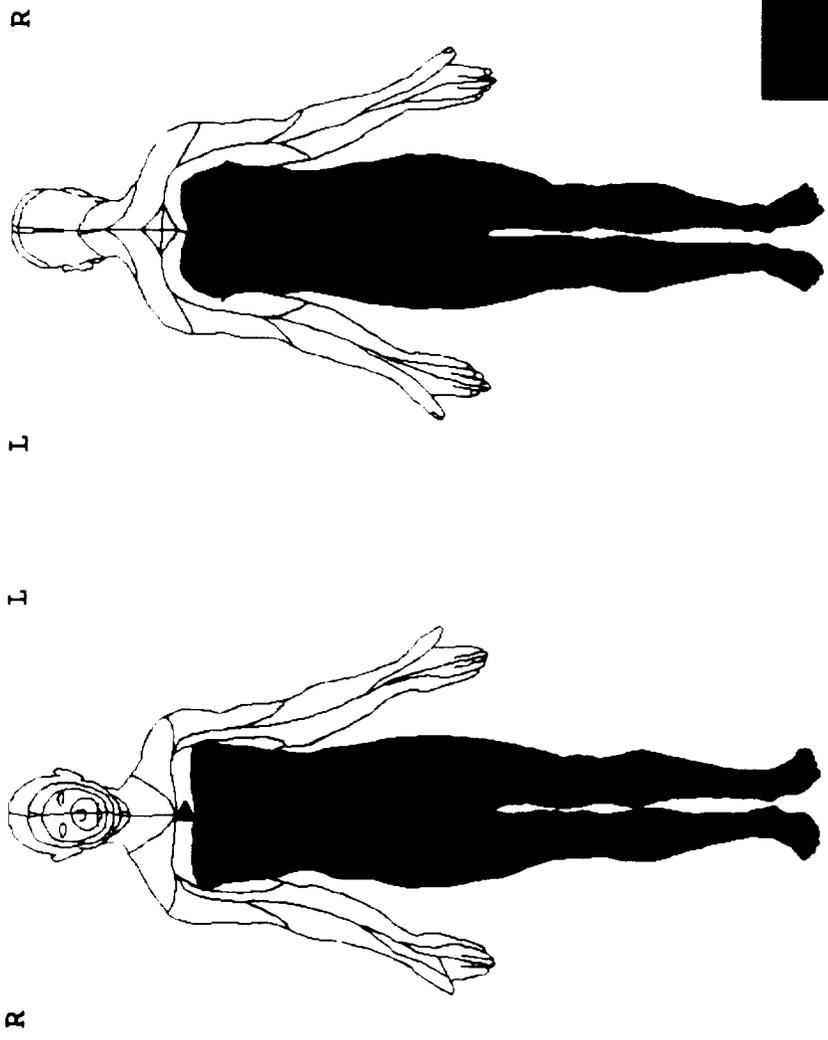


FIGURE 5

Absent

Partial

Proprioception

Stab Wound

L	L	V1	R	R	R
L	L	V2	R	R	R
L	L	V3	R	R	R
L	L	V4	R	R	R
L	L	C1	R	R	R
L	L	C2	R	R	R
L	L	C3	R	R	R
L	L	C4	R	R	R
L	L	C5	R	R	R
L	L	C6	R	R	R
L	L	C7	R	R	R
L	L	C8	R	R	R
L	L	T1	R	R	R
L	L	T2	R	R	R

T4
T5

T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5

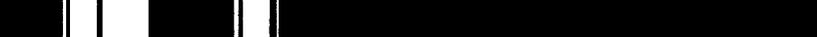
Name Last **SMITH** First **JOSEPH** Age **44** Weight **100** kg; Sex **M** Race **W**
 Height **5** ft; **4** in; Hospital ID **00078789** Trauma No **01010** SSF **217-29-31**
 ADM Date **5/30/94** Time **Day** Exam Date **14:01** **6/30/94**

R

L

L

R



Name Last **SMITH** First **JOSEPH** Age **44** Weight **100** kg; Sex **M** Race **W**
 Height **5** ft; **4** in; Hospital ID **00078789** Trauma No **01010** SSF **217-29-31**
 ADM Date **5/30/94** Time **Day** Exam Date **14:01** **6/30/94**

FIGURE 6

In cases where the spinal cord injuries are associated with spine trauma, the information presented in the skeletal figure (Figure 4) can be directly correlated with that presented in neurologic examination figure (Figure 5). Since any image can be repeated as serial examinations are made and the times of the repeated examinations are automatically recorded, a worsening condition or a favorable response to therapy can be precisely documented and this information shared with a remote observer or consultant so that definitive decision making can be made relevant to the risk of retrieval from space of an injured astronaut. The need for this information is obvious. Since a unless stabilization of a patient's physical injuries and the resulting physiologic abnormalities is obtained prior to retrieval from the Space Station, it would be extremely dangerous and indeed possibly fatal to subject an unstable patient to the hazards of a emergency return to Earth through a high gravitational stress, if a reasonable alternative in terms of stabilizing initial therapy prior to a slightly delayed retrieval were available.

While the NASA supported portion of this project is now completed, it is intention of the Principal Investigator to continue to develop additional body images and diagnostic capabilities for use in caring for trauma patients in Earth-based Intensive Care and Trauma Admitting Areas. This system will be utilized in recording diagnostic information in the care of a wide variety of patients injured by blunt or penetrating trauma.

B. THERAPEUTIC ADVISORIES (Rx)

A series of therapeutic advisories has been developed which relates the medical and surgical recommendations for

initial therapy to the specific types, location and severities of injuries delineated in the diagnostic examination diagrams. These data are based on the primary data entered and can be brought to the examiners attention by activating the Rx box present on each body image diagram. Two examples of such therapeutic advisories are shown. While these specific advisories are based on presently developed protocols, they can be changed as new information or new therapeutic regimens are developed, so as to maintain the advice as current as possible.

In Figures 7a,b,c, the recommended fluid therapy for the mock patient, Joseph Smith, age 44, weight 100 kilograms, height 6'2", sex male, shown in Figure 1, are presented. As indicated in the initial figure the burn was secondary to flame with a electrical component. The percentage of first, second and third degree burns are shown in Figure 1 and the percentage of the second and third degree burns have been cumulated as a basis for fluid therapy. This is shown in Figure 7a, where the basic data are repeated, the body surface area is computed and the fluid requirements for the first and second 24 hours are shown based on the modified Brooke Army Burn Center protocol. In this formula, crystalloid fluid replacement therapy only is used during the initial 24 hours of treatment and a combination of crystalloid and colloid fluid therapy is used in the second 24 hour period. The program computes the volumes and the rates of fluid administration as a baseline. However, therapeutic advisories are shown which indicate that the baseline rate of fluid administration is to be adjusted to maintain vital signs and

Name Last **SMITH** First **JOSEPH** Age **44** Weight **100** kg; Sex **M** Race **M**
 Height **5** ft; **4** in; Hospital ID **00078789** Trauma No **01010** SS# **217-29-31**
 INS carrier **BS CASUALTY** INS no **234343678**

Recommended fluid therapy, for patient **JOSEPH SMITH**, HOSPITAL ID=**(00078789)**

given the following data: height **74.00** inches, weight **100.00** kilograms, age **44** years
 with a body surface area of **2.26** square meters

percent first degree burn **1.3**
 percent second degree burn **6.5**
 percent third degree burn **34.5**
 percent second and third degree burn **40.9**

1st 24 hrs **8181 ml Crystalloid (Ringers Lactate)**
 during the first 8 hrs **4090 ml at 511 ml per hour**
 during the next 16 hrs **4090 ml at 255 ml per hour**
 2nd 24 hrs **6136 ml at 255 ml per hour Crystalloid (Ringers Lactate)**
2045 ml at 85 ml per hour Colloid as 5% Albumin Solution (Ringers Lactate)

Advisory:

Maintain rate of fluid administration to maintain vital signs and keep urine output at 50 to 100 ml/hr. Urine outputs greater than 100 ml/hr may mean over hydration and the rate of fluid hydration should be decreased.

Administer 5% Dextrose in water as required to avoid hypernatremia and to maintain urine output.

If the crystalloid required in first 24hrs to maintain urine output at greater than 50 ml/hr in first 12 hrs is greater than twice the estimated volume, give the remainder of fluid as 5% albumin solution in Ringer's Lactate and reduce crystalloid to 25% of that estimated above.

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- MEDIAST
- ARD
- PHYSICAL
- DISTIC
- BOWEL S
- YEND
- RIG
- REDOC
- EMESIS, I
- RECTAL

FIGURE 7A

Name Last SMITH First JOSEPH Age 44 Weight 100 kg; Sex M Race M
Height 5 ft; 4 in; Hospital ID 00078789 Trauma No 01010 SS# 217-29-31

of that estimated above.

Patients with 40-94 burn, should be invasively monitored with arterial and Swan Ganz Catheters for cardiovascular monitoring.

Cardiac inotropic agents: dobutamine 500 to 2000 micrograms per minute and if required low dose isuprel 0.25 micro gram per minute (total body dose) can be administered to maintain cardiac output in hyperdynamic state [greater than 5 liters per minute per square meter].

Monitor urine output and if it decreases as increased vascular resistance occurs (with adequate cardiac index and pulmonary wedge filling pressures), administer hydralazine 50 mg to increase urinary output by reducing vasculature. Monitor cardiac output and right atrial filling pressures during vasodilator therapy.

Obtain chest X-ray on admission and repeat daily to evaluate fluid overload or pulmonary infiltrations

Monitor plasma electrolytes (Na, K, CL, HCO3), glucose and BUN and arterial blood gases and base deficit on admission and at 4 to 6 hour intervals until patient is stable.

Monitor urine for evidence of myoglobinuria. If suspected, give mannitol 12.5 gm/liter of crystalloid and additional bicarbonate to alkalinize urine until urinary chromagens are clear.

If burn is to face or neck, intubate immediately to avoid upper airway respiratory obstruction. Maintain on assisted ventilation. If circumferential or extensive, mid lateral escharotomies may be required.

If burn is to face or neck, examine nose and mouth and do bronchoscopy if suspicion of pulmonary burn. If carbon particles in tracheobronchial tree, maintain on positive pressure ventilation with PEEP greater than 5 cm to 10 cm H2O and monitor blood gases and chest X-ray for evidence of ARDS. Some fluid restriction may be necessary, but should be accompanied by quantitative monitoring of cardiac output and urine flow.

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BOWEL S
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RIGI
KIDOC
EMESIS, R
RECTAL

FIGURE 7B

Name Last Smith First Joseph Age 44 Weight 100 kg; Sex M Race M
 Height 5 ft; 4 in; Hospital ID 00078789 Trauma No 0101d SS# 217-29-31

If circumferential burn of chest appears to be restricting ventilation, do bilateral chest wall escharotomies and monitor ventilatory tidal volumes and blood gases - especially PaCO₂ or end tidal CO₂ for evidence of hypercarbia.

If limb burn is circumferential or very extensive, monitor distal pulses (palmar or plantar arch) by doppler and do lateral fasciotomies to prevent vascular compromise. Fasciotomies may be done on both midlateral and midmedial sides of the limb and may need to extend over joint at elbow, wrist, knee or ankle to prevent vascular flow restriction. All compromised fascial compartments of lower leg must be opened. Tissue pressures can be monitored by needle pressure measurements of each compartment as a guide to the need for fasciotomy.

Insert nasogastric tube for gastric decompression until ileus resolves.

Institute gastric anti-acid therapy with H₂ blocker (e.g. pepsid 40 mg IV bid).

Administer tetanus toxoid booster if last booster greater than 5 years ago. If no prior immunization, also give 250-500 units of human anti-tetanus globulin. In cases involving compromised adults, administer penicillin 2000000 units, after checking for penicillin allergy.

Cleanse burn wound with surgical detergent, trim away all non-viable skin or hair. Apply topical agent such as silvadene 1% burncream to debride areas. If the eschar over 3rd degree burns is dense, sulfamylon burn cream [11.1% mafenide acetate] may be required until debridement of the eschar is possible. However, use of this agent is kaliuretic and may produce hypokalemic alkalosis.

Early excision of 3rd degree (full thickness and deep partial thickness) burns should be carried out as soon as possible after resuscitation is completed.

Monitor ECG for at least 24 hours for evidence of arrhythmias.

Fasciotomy of involved extremities should be performed to prevent increased compartment pressures and ischemic necrosis of uninvolved muscle. Non-viable tissue should be debrided and all muscles must be explored for necrosis. For electrical burns, prompt amputation should be done for extensive limb destruction.

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FIGURE 7C

to keep the urine output between 50-100 milliliters per hour. Cautions regarding the use of dextrose: salt solution modifications in the replacement fluid therapy appropriate to the patient's needs are discussed. The requirements for physiologic monitoring of patients with large burns, the percent burn sustained by Mr. Smith (40.9 percent) is noted, and the use and body weight adjusted dosage of inotropic agents to maintain a high cardiac output in the hyperdynamic range are shown. The use of agents to combat excessive vasoconstriction is noted and specific cautions as to when to obtain serial chest x-rays to evaluate fluid overload by pulmonary infiltration are shown. The need for frequent monitoring of plasma electrolytes, glucose and blood urea nitrogen, as well as blood gases is indicated and their frequency indicated.

Since the patient has noted to have an electrical component to his large third degree burn, a warning is given to monitor the urine for evidence of myoglobinuria and a therapeutic program for urine alkalization to prevent renal failure is indicated. Since the patient was shown to have a circumferential burn, of face and neck, the need to consider airway intubation and the possibility of early escharotomy with regard to both the neck and the chest are indicated in subsequent cautions. The need to evaluate the patient for evidence of respiratory burn and the preferred diagnostic technique (bronchoscopy) is indicated. The presence of a circumferential limb burn is noted and the need for monitoring of extremity pulses and fascial compartment pressures is indicated with a requirement for limb fasciotomy should these

compartment pressures be elevated.

The use of general therapeutic modalities such as the use of a nasogastric tube and or gastric antacid therapy as well as its dose are noted. The importance of tetanus toxoid and antibiotic prophylaxis against staphylococcus and streptococcus organisms is indicated. The approach to wound cleansing and local antibiotic suppressant therapy is suggested. Finally, the use of early excision of the areas third degree burns is recommended and because of the electrical component, a monitoring of ECG and the exploration of all extremities involved in the electrical burn is indicated for the identification of necrotic muscle. The need for early amputation for extensive muscle damage due to an electrical burn is also noted.

Since barotrauma represents a major medical complication of extravehicular activity in any space environment, a set of recommendations for the treatment of severe barotrauma are shown for a mock patient, Max Gerber, who has been identified as having barotrauma by **E Code**, complicated by the presence of a probable pneumothorax by physical examination. In the set of therapeutic advisory cautions shown in Figures 8a,b & c, the examining physician or paramedic is alerted to signs and symptoms of barotrauma due to micro embolic gas bubbles which obstruct capillary blood flow and warned about the most severe manifestations of the air embolus syndrome which are related to central nervous system involvement. The need to quantify the distribution of any spinal cord lesions is noted and the importance of a careful neurologic examination with

Name Last gerber First max Age 42 Weight 72 kg; Sex M Race B
 Height 5 ft; 11 in; Hospital ID 727274 Trauma No SS#
 INS carrier INS no
 Address City State Zip
 ADM Date 1/13/94 Time 11:28 Day Exam Date 11:24 01/13/94

Stab wound

Patients sustaining barotrauma due to acute decompression may give evidence of microembolic phenomena due to small bubbles of nitrogen in the microvasculature. These may produce the signs and symptoms of ischemia. In muscle beds, they may produce severe pain due to the localized muscle ischemia known as "the bends". In skin, ischemia caused by gas microemboli may be associated with tingling, pain or "a crawling sensation".

However, the most severe manifestations of this phenomena lie in the central nervous system. In the spinal cord, partial paralysis or sensory losses with a variable distribution may occur. In the brain, air microemboli may produce confusion or coma. The distribution of the spinal lesions should be carefully mapped and quantified. The level of brain disfunction should be quantified by a careful examination and Glasgow Coma Scale scoring.

Acute decompression barotrauma may also induce a rupture of the lung alveolae and a sudden pneumothorax may ensue. In rare instances, this may progress to a tension pneumothorax with unilateral pressurized lung collapse, leading to a shift in the mediastinum evidenced by a tracheal shift AWAY from the side of the pneumothorax. The breath sounds will be diminished or absent in any pneumothorax. In a tension pneumothorax, therapy is necessary on an emergency basis. A hollow needle, open to the atmosphere must be immediately inserted into the chest on the side of the pneumothorax, to allow acute decompression of the tension pneumothorax.

Any pneumothorax, whether accompanied by acute tension or merely lung collapse, should be treated by chest tube insertion and water seal decompression with suction to expand the lung. If these are not possible, a Heimlich valve can be inserted through the chest wall, to allow a controlled air leak and decompression of the tension pneumothorax. The use of this device or an acute needle decompression WILL NOT EXPAND THE COLLAPSED LUNG and a large pulmonary shunt is to be expected. A high inspired O2 partial pressure should

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 RIGID
 REDON
 EMESIS, NC
 RECTAL

FIGURE 8A

Name Last **Gerber** First **Max** Age **42** Weight **72** kg; Sex **M** Race **H**
 Height **5** ft; **11** in; Hospital ID **727274** Trauma No. **SS#**
 INS carrier **INS no**
 Address **City** State **Zip**
 ADM Date **1/13/94** Time **11:28** Day **Exam Date 11:24 01/13/94**

and a large pulmonary shunt is to be expected. A high inspired O2 partial pressure should be used (i.e. 100% O2), to compensate for the shunt.

Neurological signs of spinal cord or brain ischemia require emergency hyperbaric therapy. These severe lesions, will usually require urgent hyperoxia, at two to three atmospheres, using 100% oxygen. Patients with neurological impairment, who are comatose (Glasgow Coma Scale score < or = 8) or confused (13 > Glasgow Coma Scale score < 8) require airway protection. The comatose patient will need intubation of the upper airway (nasotracheal or endotracheal tube insertion). These patients may have a respiratory arrest, as the inspired partial pressure of O2 is increased, reducing any hypoxic ventilatory drive. They must be prevented from having any rise in PaCO2, which will increase brain swelling. They must be ventilated, either by a simple mechanical respirator or by bag breathing via the endotracheal tube. The arterial O2 saturation and the PaCO2 (using either endtidal CO2 tension or transcutaneous PCO2) need to be measured to prevent the PaCO2 levels from rising above 40 torr or falling below 30 torr. In some cases of severe brain edema, a low PaCO2 may be useful in reducing brain swelling, but maintaining levels below 30 torr is to be avoided. In these patients, large quantities of intravenous fluids should be avoided, but maintenance of a high cardiac output is desirable, to prevent a fall in perfusion associated with hyperoxic vasodilation. Utilize low dose isoproterenol (0.25-0.50 micrograms/min total dose) or dobutamine (360.00-720.00 micrograms/min total dose) and small volumes of colloid to maintain hyperdynamic cardiovascular response. Unexpected bradycardias may occur due to increases in Vagal tone and atropine 0.5 to 1.0 mg IV should be given if the heart rate drops below 60 b/min.

Patients with spinal cord dysfunction should receive an immediate intravenous bolus of Methylprednisolone (2160 mg) over a 15 minute period. After 45 minutes, give 389 mg/hour for the next 23 hours, then discontinue steroid therapy.

Insert nasogastric tube in all comatose patients to prevent gastric regurgitation and aspiration.

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- TRACHEAL S
- PNEUMOTHOR
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- HEART SOC
- MEDIASTIN
- ABDOM
- PHYSICAL +
- DISTEND
- BOWEL SOC
- TENDER
- RIGID
- REBOUN
- EMESIS, NG
- RECTAL

FIGURE 8B

Name Last (perbed) First (max) Age 44 Weight 72 kg; Sex M Race H
 Height 5 ft; 11 in; Hospital ID 727274 Trauma No. SS#
 INS carrier
 Address City State zip
 ADM Date 11/13/94 Time 11:28 Day Exam Date 11:24 01/13/94

aspiration.

A Foley catheter should be inserted in comatose or paralyzed patients to prevent bladder distention and to monitor urine output. Some patients with severe brain edema, due to anoxic injury, will manifest diabetes insipidus (DI). An excessive urine output/input should alert to this possibility. Presence of a dilute urine with low specific gravity ($< \text{or} = \text{one sigma}$) in the face of an increasing serum Na^+ ($\text{Na} > \text{or} = 150 \text{ mEq/L}$) should be considered as presumptive evidence of DI. Replace urine volume with 5% glucose in 0.2% Sodium Chloride or 0.2% Ringers solution on an hourly basis until serum Na^+ returns to normal. If the DI persists administer Vasopressin 2.5 to 5.0 units IM, followed by 0.1 to 0.2 ml (20U) of aqueous Vasopressin q4-8hrs until urine output is reduced below 200 ml/hr.

Prior to initiating hyperbaric therapy in comatose, intubated or paralyzed patients who cannot adjust middle ear pressure to atmospheric pressure by swallowing, bilateral myringotomies should be performed to equalize pressure and prevent ear drum rupture. This can be done using an otoscope and a sterile #18 needle.

The initiation of hyperbaric therapy should be done gradually to 2 atmospheres of pressure. Usually, the maximum hyperbaric level should be maintained for only one hour, with slow decompression at approximately one hour per atmosphere above normobaric, using Navy decompression schedules.

Patients undergoing hyperbaric therapy, who are comatose, paralyzed, or who have any degree of confusion or disorientation or, who have other medical or surgical conditions MUST be attended by medically trained personnel and have continuous physiologic monitoring during the entire period of hyperbaric therapy. This means, all medications, fluids and medical equipment must be placed in the chamber before hyperbaric therapy is begun.

- CHE
- FLAIL CHE
- PARENCHYMAL
- TRACHEAL S
- PNEUMOTHOR
- HEMOTHOR
- SUCKING W
- HEART SOC
- MEDIASTIN
- ABDOM
- PHYSICAL +
- DISTEND
- BOWEL SOC
- TENDER
- RIGID
- REBOUND
- EMESIS, NC
- RECTAL

FIGURE 8C

delineation of a Glasgow Coma Scale Score is particularly stressed. Because of the questions of acute decompression, barotrauma related to rupture of lung alveoloe with consequent pneumothorax is stressed and the characteristics of acute pneumothorax and especially acute tension pneumothorax are indicated. If a tension pneumothorax has been identified in the initial examination, the use of immediate needle decompression followed by chest tube suction, or Heimlich valve protection are indicated, and the limitations of techniques (Heimlich valve) that do not expand the lung are noted, since they require remedial oxygen therapy.

A particularly important component of this warning is related to the presence of any neurologic examination indication of spinal cord or brain ischemia, since these complications imply a need for emergency hyperbaric therapy. In the presence of coma, the indications for therapy to modify the neurologic impairment are delineated. The need for intubation and ventilation to prevent hypoxemia and more important to prevent hypo-ventilation with a rise in arterial CO₂ are noted, as well as the consequences of hypercarbia resulting in increased brain swelling which needs to be prevented. Technique for evaluation of these abnormalities is indicated. The techniques needed to maintain a high cardiac output in the presence of a low intravascular volume expansion are stressed.

Most important barotrauma patients with spinal cord disfunction are delineated as mandatorily requiring a therapeutic dose of corticosteroids and the steroid dose and

dosing program, computed on the basis of the patient's body weight, are given. Additionally, the need for nasogastric tube decompression in comatose patients is indicated. The role of foley catheter decompression to prevent bladder distention, especially if spinal cord injury is present, is stressed and the importance of the recognition of diabetes insipidus (DI) is noted and a program for DI replacement therapy and the use of vasopressin therapy to control the excessive renal fluid losses is prescribed.

Finally, the importance of myringotomy before hyperbaric therapy to equalize the air pressure gradient across the ear drums is noted. The general level of hyperbaric pressures required for therapy and the role of slow decompression from hyperbaric therapy using the Navy decompression schedule is emphasized. Finally the importance of evaluation of the comatose or paralyzed patient with regard to detecting other occult medical or surgical conditions is emphasized, so that the complete examination of these patients can be carried out. The final caution notes that because of the delay in having access to such a patient once hypobaric therapy has begun, there is a need to replace all needed medical personnel and all modalities for therapy within the hyperbaric chamber prior to initiation of the hyperbaric therapy.

While the specific cautions shown can be modified at any time to reflect changes in the recommended therapy or improved diagnostic capabilities, their inclusion provides examples of how the physical examination and physiologic studies captured in the diagnostic examination portion part of the program can

be used to direct and modulate the therapy of the acutely injured patient. This becomes especially important when such patients may have to be managed by individuals who are not skilled in acute trauma or intensive care management and where their diagnosis and therapy may have to be carried out at a location far from a definitive hospital setting, or in circumstances where communication may be disrupted and transportation from the location of injury to a definitive care facility may be delayed or prevented for a critical period.

C. TEST AND EVALUATION

The initial evaluation of the utility of these modules has begun in the Principal Investigator's clinical facility. The diagnostic modules shown have been utilized in the recording and evaluation of data from patients injured in motor vehicle crashes and this controlled system evaluation has resulted in some important additions and modifications to the original diagnostic diagrams. Even though the NASA grant has ended, the Principal Investigator is continuing this study and adding additional modules suitable for in-hospital diagnostic and therapeutic evaluation as well as for the recording for surgical therapeutic maneuvers. Other aspects of this study which go beyond the original NASA project are related to the interrelationship of these data to diagrams of the structure of the passenger compartments of motor vehicles. These are done in order to access the causative factors and points of contact resulting in patient motor vehicle injuries. In addition, a series of more detailed and elaborate diagrams

which are suitable for specialty service examination beyond the initial assessment are being developed. In these programs the specific injuries, their complications and the relevant therapeutic maneuvers are being correlated with the appropriate diagnostic and therapeutic codes (ICD9, CPT codes, etc.) utilized by various organizations and governmental agencies. Eventually, it is planned that this computer based system will be utilized to gather the data for a contemporaneously generated trauma registry and will be related to statistical and statistics graphic programs for presentation of group data. Thus, the NASA grant, although limited in scope has permitted an initial exploration of this area and serves as a basis from which a comprehensive system of computer based trauma diagnosis and care is being developed.

D. TECHNICAL ORGANIZATION OF PROGRAMMING SYSTEM

The medical graphics user interface application is designed to utilize a library of real time transaction processing objects. These objects are written utilizing the American National Standard for Information Systems - Programming language C, ANS X3.159-1989, as well as The National Institute of Standards and Technology, (formerly the National Bureau of Standards), Portable Operating System Interface for Computer Environments (POSIX) in order to comply to the Federal Information Processing Standard. All graphics are performed with X11 from the X consortium and the Open Software Foundation's Motif toolkit, operating with Release 5.

The use of these standards has produced a highly portable client/server application, which can segment functionality across a network. The 4 base functions are 1) database access; 2) terminal I/O; 3) system administration; 4) CPU utilization. The segmentation of the system produces an ideal environment for mobile light weight and compact X-terminal emulators performing graphic output and terminal input while communicating via TCP/IP through a mobile phone, radio or satellite dish to a central computer or ground station. We are presently acquiring a laptop computer for remote testing of a serial line interface protocol. In addition, we have fully tested the use of remote databases, CPUs and administration.

The objects fall into configurable classes which are reused across the suite of programs. The major classes of objects include:

- 1) The drawing class: a graphics area responsible for editing injury symbols, adding them to, or removing them from, an anatomical drawing and pointing to the anatomical name if available.
- 2) The command class: permits the user to select a new injury code, informs the user of the present selected injury code and maintains the injury symbol legend.
- 3) The advisory class: informs the user of any medical information that may be useful for the particular trauma conditions.

- 4) The database class: permits the uses to list the patients (or selectively search for patients), list a patient's examination history, show a patient's examination, file a new examination, edit an erroneous exam (password protected) and delete an examination or patient (password protected).

- 5) The terminal I/O class: permits the user to type or modify patient information.

- 6) The choice class: permits the user to indicate a condition from a list of possible conditions. This class is used for:
 - a. Chest exam + x-ray
 - b. Abdominal exam + x-ray
 - c. Glasgow Coma Scale Scoring
 - d. Central Nervous System and spinal neurologic function tests
 - e. indicators of sinus fractures and CNS fluid leaks, classifications of types facial fractures by LeFort class
 - f. Central Nervous System Brain hematomas
 - g. Joint sprains
 - h. Joint ligament disruption
 - i. Joint or vertebral dislocations
 - j. Classes to be defined